AN INTERFERENCE DISPLAY CELL AND FABRICATION METHOD THEREOF

Field of Invention

The present invention relates to a method for manufacturing an optical interference display. More particularly, the present invention relates to a method for manufacturing an optical interference display with posts of arms.

Background of the Invention

Planar displays are popular for portable displays and displays with space limits because they are light and small in size. To date, planar displays in addition to liquid crystal displays (LCD), organic electro-luminescent displays (OLED), plasma display panels (PDP) and so on, as well as a mode of the optical interference display are of interest.

US Patent No. 5,835,255 discloses an array of display units of visible light that can be used in a planar display. Reference is made to figure 1, which depicts a top view of a light interference display unit disclosed in the prior art. A plurality of first electrodes 102 is located in parallel on a substrate 100. A plurality of the second electrodes 104 is located in parallel on the first electrodes 102 and is arranged vertically with the first electrodes 102. A plurality of posts 106 is located between the first electrode 102 and the second electrode 104, and a cavity (not shown) is subsequently formed. Reference is made to figure 2, which depicts a cross-sectional view according to a cutting plane line I-I' in figure 1. Every optical interference display unit 108 comprises two electrodes, 102 and 104. Posts 106 support these two electrodes 102 and 104, and a cavity 110 is subsequently formed. The distance between these two electrodes 102 and 104, that is, the length of the cavity 110, is D. One of the electrodes 102 and 104 is a semi-transmissible/semi-reflective layer with an

absorption rate that partially absorbs visible light, and the other is a light reflective layer that is deformable when voltage is applied. When incident light passes through the electrode 102 or 104 and arrives in the cavity 110, in all visible light spectra, only visible light with wavelength corresponding to formula 1.1 can generate a constructive interference and can be emitted, that is,

$$2D = N\lambda \qquad (1.1)$$

where N is a natural number.

When the length D of cavity 110 is equal to half the wavelength times any natural number, a constructive interference is generated and a sharp light wave is emitted. In the meantime, if the observer follows the direction of the incident light, a reflected light with wavelength λ_1 can be observed. Therefore, the display unit 108 is "on".

One of the first electrode 102 and the second electrode 104 is a deformable electrode or a movable electrode. It shifts up and down by applying a voltage. While driven by the voltage, the deformable or movable electrode is deformed and falls down towards another electrode due to the attraction of static electricity. At this time, the distance of the length of the cavity 110 changes. All incident light in the visible light spectrum is filtered out and an observer who follows the direction of the incident light cannot observe any reflected light in the visible light spectrum. The display unit 108 is now "off".

Referring again to figure 1, besides the post 106, support structure 112 is located between two second electrodes 104 to support the second electrode 104. Without the support structure 112, the edge of the second electrode 104 sags down due to a lack of support. Therefore, the length of the cavity 110 is not uniform. For the display unit 108, non-uniformity of the length of the cavity 110 results in reflected light with at least two different wave-lengths;

therefore, the resolution of the reflected light becomes worse and the display unit may display more than one color.

Reference is made to figure 3A, which depicts a cross-sectional view according a cutting plane line II-II' in figure 1. The method for forming the structure illustrated in figure 3A is depicted in figure 3B. A transparent conductive layer, a absorption layer and a dielectric layer (all not shown) are formed sequentially on a transparent substrate 100. The transparent conductive layer, the absorption layer and the dielectric layer form a first electrode 102. A sacrificial layer 114 is then formed on the first electrode 104. The material for forming the dielectric layer comprises silicon oxide and silicon nitride; the material for forming the transparent conductive layer comprises indium tin oxide, indium zinc oxide and indium oxide; and the material for forming the absorption layer is metal. Next, a lithography process and an etching process are performed to form an opening 116 in the sacrificial layer 114 and the first electrode 102. A photoresist layer is spin-coated on the sacrificial layer 114 and fills the opening 116. An exposure process is performed on the photoresist layer and a support structure 112 is formed in the opening 116.

A conductive layer 118 is formed on the support structure 112 and sacrificial layer 114. A spin-coating process and a lithographic process are performed sequentially to form a patterned photoresist layer 120 on the conductive layer 118. An opening in the patterned photoresist layer 120 exposes the underlying conductive layer 118 located on the support structure 112. The patterned photoresist layer 120 is used as an etching mask to remove the exposed conductive layer 118; then, the second electrode 104 settled in parallel with the first electrode 102 illustrated in figure 1 is formed. Finally, the photoresist layer 120 is removed and the optical interference display unit 108 is formed.

Generally, a material used to form the support structure 112 is photoresist; therefore, the support structure 112 is always damaged or removed completely in the step of removing the photoresist layer 120 and a structure illustrated in figure 3C is formed. Reference is made to figure 3C, which depicts cross-sectional views of an optical interference display unit which lack the support structure. Because the support structure is damaged or removed, the edge of the second electrode 104 gets no support and sags in a direction indicated by arrow 105. The length of the cavity 110 is not uniform because of the sagging edge of the electrode 104. Therefore, the disadvantages of a worse resolution and wrong color of the optical interference display unit can't be avoided.

Therefore, it is an important subject to provide a simple method of manufacturing an optical interference display unit structure, for manufacturing a color optical interference display with high resolution, high brightness, simple process and high yield.

Summary of the Invention

It is therefore an objective of the present invention to provide a method for manufacturing an optical interference display unit structure, which method is suitable for manufacturing a color optical interference display with high resolution.

It is another an objective of the present invention to provide a method for manufacturing an optical interference display unit structure, which method is suitable for manufacturing an optical interference display with a simple and easy manufacturing process and high yield.

It is still another objective of the present invention to provide a method for manufacturing an optical interference display unit structure, which method is suitable for manufacturing optical interference display units where the support structure of the optical interference display unit is not damaged or removed in

the process, and which is used to remove the photoresist layer and provide a high quality optical interference display plate.

In accordance with the foregoing objectives of the present invention, one preferred embodiment of the invention provides a method for manufacturing an optical interference display unit structure. The method for manufacturing an optical interference display unit structure disclosed in the present invention protects the support structure from damage or removal by the process, which is used to remove the photoresist layer on the second electrode. The method of fabricating the optical interference display unit structure is to form sequentially a first electrode and a sacrificial layer on a transparent substrate, and then form openings in the first electrode and the sacrificial layer. The openings are suitable for forming posts and support structure therein. Next, a photoresist layer is spin-coated on the sacrificial layer and fills the opening. A photolithographic process patterns the photoresist layer to define a post and the support structure.

At least one first material layer is formed on the sacrificial layer, the post and the support structure after the post and the support structure is formed. A second material layer is then formed on the first material layer. A patterned photoresist layer, which is used as a mask for the next etching process, is formed on the second material layer. An etching process is performed to remove the exposed second material layer and expose a portion of the first material layer and the pattern of the photoresist layer is transferred to the second material layer. The photoresist layer is stripped and the second material layer is used as an etching mask to etch the first material layer to define the second electrode. While stripping the photoresist layer, the support structure is covered and protected by the first material layer, and the support structure is not damaged or removed by the process. Finally, a release etch process is performed to remove the sacrificial layer and an optical interference display unit structure is formed.

The material for forming the second material layer can be any material, capable of transferring the pattern of the photoresist layer thereon and an etch mask while the process for etching the first material layer is performed. Because the second electrode is a deformable electrode or a movable electrode, the preferred material for forming the second material layer is a ductile material, such as metal.

The material for forming the first material layer and the second material layer can be the same, but different is better. Furthermore, if the etching selectivity ratio between the first material layer and the second material layer is not high enough, the second material layer is etched when the etching process to the first material layer is performed, and the thickness of the second material layer becomes thinner than originally intended. The thickness of the second electrode (including the thickness of the second material layer) affects the stress of the second electrode and the operative voltage of the optical interference display unit. How much voltage should be used to operate the optical interference display unit if the thickness of the second material layer after etching process is altered is not known. For the reason disclosed above, the preferred material for forming the second material layer has a high etching selectivity ratio compared to the material for forming the first material layer.

In accordance with the method for manufacturing an optical interference display unit structure in present invention, at least two material layers are used to form the second electrode. The material layer located on the upper position is used to transfer the pattern of the photoresist layer thereon and the other material layers are used to protect the support structure from damage in the process for stripping the patterned photoresist layer. Concurrently, an optical interference display plate with high quality is produced. Therefore, the present invention discloses a method for manufacturing an optical interference display with a simple and easy manufacturing process and high yield.

It is to be understood that both the foregoing general description and the following detailed description are examples, and are intended to provide further explanation of the invention as claimed.

Brief Description of the Drawings

These and other features, aspects, and advantages of the present invention will be more fully understood by reading the following detailed description of the preferred embodiment, with reference made to the accompanying drawings as follows:

Figure 1 depicts a top view of a light interference display unit disclosed in the prior art;

Figure 2 depicts a cross-sectional view according to a cutting plane line I-I' illustrated in the figure 1;

Figures 3A depicts a cross-sectional view according to a cutting plane line II-II' illustrated in the figure 1;

Figure 3B depicts a method for forming the structure illustrated in figure 3A;

Figure 3C depicts cross-sectional views of an optical interference display unit, which lacks of the support structure; and

Figures 4A to 4D depict a method for manufacturing an optical interference display unit according to one preferred embodiment of this invention.

Detailed Description of the Preferred Embodiment

In order to provide more information of the optical interference display unit structure, the preferred embodiment is provided herein to explain the optical interference display unit structure in this invention.

Embodiment

Figures 4A to 4D depict a method for manufacturing an optical interference display unit according to a preferred embodiment of the invention. Reference is made to figure 4A first, in which a first electrode 402 and a sacrificial layer 404 are formed in order on a transparent substrate 400. The sacrificial layer 404 is made of transparent materials such as dielectric materials, or opaque materials such as metal materials. Opening 406 is formed in the first electrode 402 and the sacrificial layer 404 by a photolithographic etching process. The opening 406 is suitable for forming a support structure therein. The transparent substrate 400 is, for example, a glass substrate and the first electrode 402 comprises at least one conductive transparent material layer. The conductive transparent material is indium tin oxide (ITO), indium zinc oxide (IZO), or indium oxide (IO).

Next, a material layer 408 is formed on the sacrificial layer 404 and fills the opening 406. The material layer 408 is suitable for forming support structures and posts, and the material layer 408 generally uses photosensitive materials such as photoresists, or non-photosensitive polymer materials such as polyester, polyamide or the like. If non-photosensitive materials are used for forming the material layer 408, a photolithographic etch process is required to define support structures and posts in the material layer 408. In this embodiment, the photosensitive materials are used for forming the material layer 408, so merely a photolithographic etching process is required for patterning the material layer 408.

Reference is made to figure 4B, in which the support structure 410 and posts (not shown in the scheme) are defined by patterning the material layer 408 during a photolithographic process. After this step, a second material layer 412 and a third material layer 414 are formed sequentially on the sacrificial layer 404 and support structure 410. The second material layer 412 and the third material layer 414 are adapted to form a second electrode;

therefore, the material of at least one material layer is conductive material, such as, for example, aluminum, chromium, copper, or cobalt. The material for forming another material layer is metal or dielectric, such as, for example, aluminum, chromium, copper, cobalt, silicon nitride or silicon oxide. The materials for forming the second material layer 412 and the third material layer 414 are aluminum and chromium. Furthermore, the material for forming the second material layer 412 and the third material layer 414 are chromium and aluminum.

Reference is next made to figure 4C. A patterned photoresist layer 416 is formed on the third material layer 414. The patterned photoresist layer 416 has an opening 418, which is located upon the support structure 410. The patterned photoresist layer 416 is used as an etching mask and an etching process is performed to etch the third material layer 414 to form an opening 420. The opening 420 exposes portion of the second material layer 412. The pattern of the patterned photoresist layer is transferred to the third material layer 414.

Reference is made to figure 4D. The patterned photoresist layer 416 illustrated in figure 4C is removed. The third material layer 414 is used as an etching mask and an etching process is performed to etch the exposed second material layer 412 to define a second electrode 422. Finally, a release etch process is performed to remove the sacrificial layer 404 illustrated in figure 4C and an optical interference display unit 424 is formed.

Because the material used to form the support structure comprises positive photoresist, negative photoresist, and polymer, such as, for example, acrylic resin and epoxy resin, the material is damaged or removed in the process performed to remove the photoresist layer 416 if the second material layer is absent. Because the support structure is damaged or removed, the edge of the second electrode gets no support and sags. The length of the cavity is not uniform because of the sagging edge of the electrode and the wavelength of the reflective light is thus not uniform; therefore, the resolution of the optical

interference display plate becomes worse. However, the present invention discloses a method for fabricating an optical interference display unit, in which a material layer is formed on the support structure to protect the support structure and avoid damaging the support structure during the photoresist layer stripping process. Furthermore, the material for forming the second material layer 412 and the third material layer 414 also can be metal/dielectric or dielectric/metal, such as aluminum/silicon nitride or silicon nitride/aluminum.

Although the present invention has been described in considerable detail with reference certain preferred embodiments thereof, other embodiments are possible. Therefore, their spirit and scope of the appended claims should no be limited to the description of the preferred embodiments container herein. In view of the foregoing, it is intended that the present invention cover modifications and variations of this invention provided they fall within the scope of the following claims and their equivalents.